Characteristic angles of inserted blade milling cutters

The inserted blade milling cutters are made of a steel body on which are fixed in their seats, the blades of high speed steel or carbide forming the cutting edges.
Nowadays we use almost exclusively the insert milling cutters, using carbide inserts, of various shapes, instead of regrindable blades.
This type of cutter is used for milling large areas, sometimes on very powerful machines, such as processing large structures for machine tools, but they are also very popular in the automotive industry to plane, engine blocks, gear boxes, and other components of a certain size.
The schematic figures shown below refer to the classic inserted blade milling cutters , but all considerations exposed is also valid for insert milling cutters.
The two most important angles that determine the position of the blades are the axial and radial angle.
Each can be positive or negative and there are four possible combinations of these angles.

a)- Negative axial angle and negative radial angle (fig. N°1a)
b) - Positive axial angle and negative radial angle (fig. N°1b
c) - Positive axial angle and positive radial angle (fig.N°1c)
d) - Negative axial angle and positive radial angle . Rarely used.

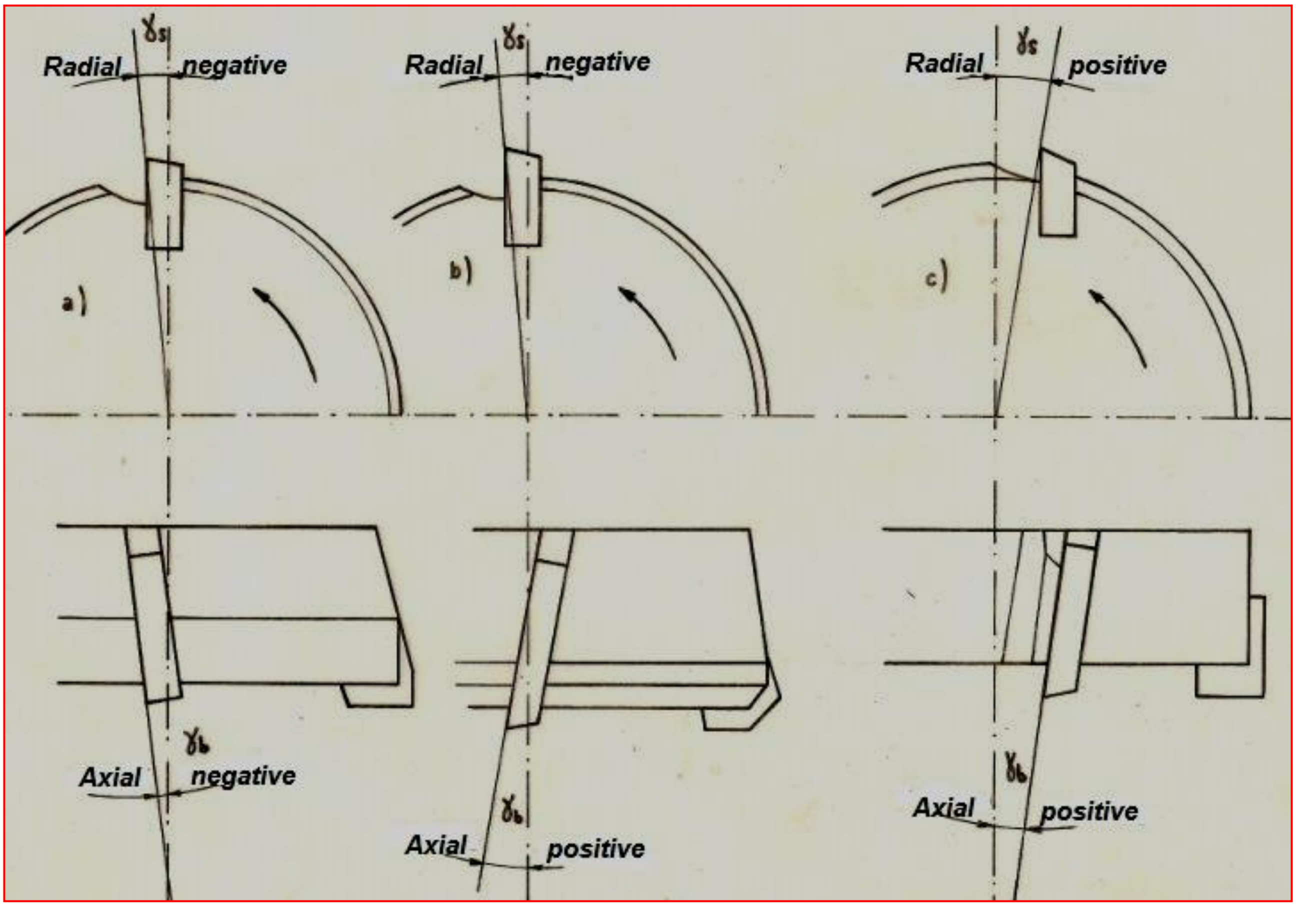

Fig. N°1- *Schematic indication of the various combination of the typical angles*

The combination c), both positive axial and radial angles, is used in the milling cutters so-called "universal", ie those milling cutters used in various processes, ie milling steel, cast iron and nonferrous materials.
It is used both in roughing and finishing operations, and is particularly suitable for older machines with limited power.
The blades may also be in high speed steel, but today almost all using blades or inserts in carbide.

The combination b), axial angle positive and radial angle negative, is the composition more complex because it generates a significant variation of the effective angles of the cutting edges.
In fact, in most cases, although it may appear that the cutter works with a negative rake angle, in effect are working with a positive rake angle.
The combination a), both negative angles, is exclusively used for milling cutters with blades or inserts in carbide, because it is known as high speed steel cutting edges are not suitable for negative rake angles .
This last type of milling cutter is used for machining high-strength materials and is also the most frequently used in the insert milling cutters because it allows the use of all the cutting edges of the insert.
It should be noted immediately that the modern insert milling cutters using inserts in carbide coated with TiN or other products, which almost always have the chip breakers, sometimes with sophisticated shapes, which significantly altered the theoretical angles above.
But in principle the values of these angles can be the following:

- *For steel: from -5° to -10°*
- *For cast iron : from 0° to +7°*
- *For aluminum and light alloys: from +7° to +15°*

<u>Angle of peripheral cutting edge</u>

Further complicating the study of the properties of the cut also contributes the cutting edge angle, ie how the cutting edge attacks the workpiece.
From this depends the size of the chip, the directions and intensity of the forces which it is subject the cutter and ultimately the life of cutting edges themselves.
Generally this angle is always advisable where the presence of shoulders do not impede the application, because the life of the cutting edges is significantly extended.
Suffice it to observe now that, As you can see in Figure N ° 2, with increasing of this angle the cutting edge load is distributed over a larger area and therefore the pressure (specific load) is reduced, decreasing the possibility of chipping and breakages.

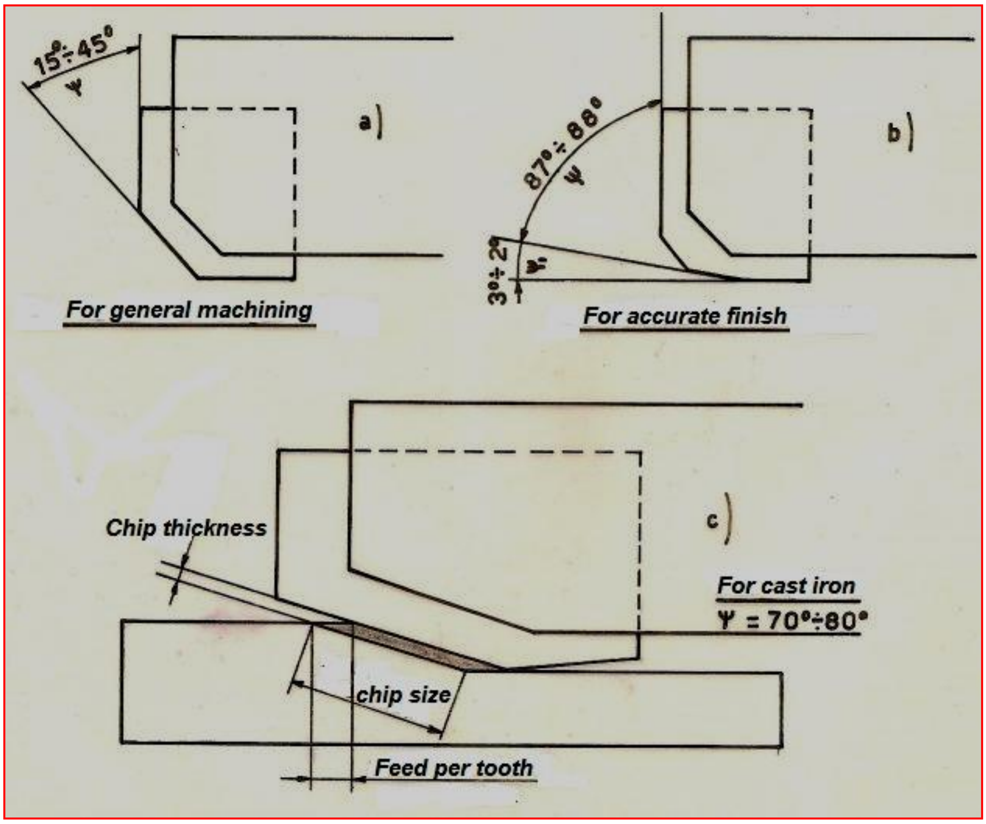

Fig. N°2- *Different angles of peripheral cutting edge*

The inclination of the peripheral cutting edge can vary generally from 15° to 45° in relation to the cutter axis.
In the processing of cast iron, with strong depth of cut, the peripheral angle can reach 70° to 80°, thus reducing the chip thickness and its width increases.
Because the load on the cutting edge is more distributed, there is also the possibility to increase the feed, if the available power is sufficient.
In very accurate finish operations the angle of inclination can be up to 88°, but this may reduce the life of the cutting edge because the chip is too thin.
The grooving milling cutters are often built with two cutting edges with negative inclinations (see figure N°3) and for this reason are called milling cutters bi-negative or biaxial.

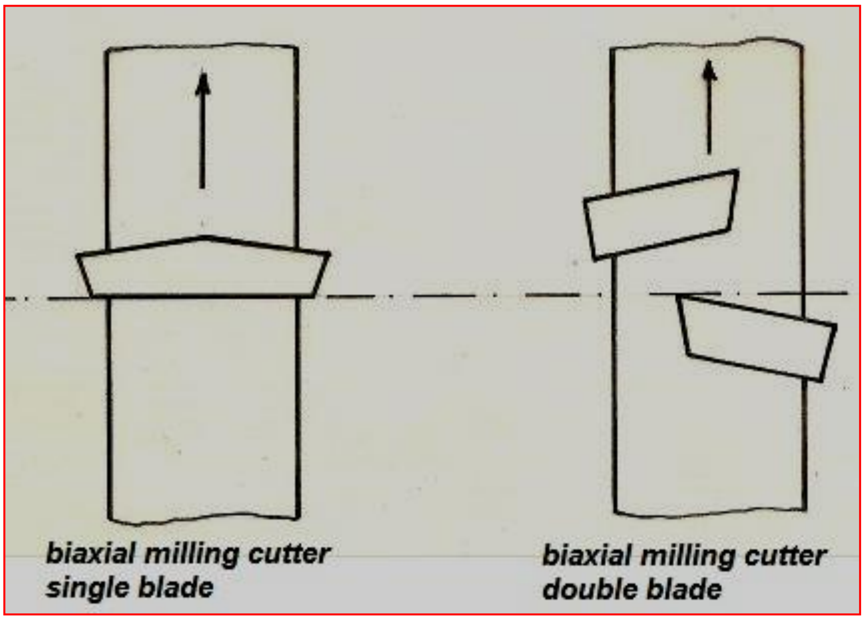

Fig. N°3- *Milling cutter with bi-negative inclination of the cutting edges*

With this system, the edges are sufficiently strong on both sides and the chips are pushed outward to avoid clogging in the center of the groove.
In the milling cutters of small thickness is used the system shown in figure N°3a, that is, a single blade with two inclinations, while in the milling cutters with bigger size are mounted alternated blades as shown in figure N°3b.
We have already mentioned that the combination of the angle axial, radial and peripheral changes the effective rake angles, ie the angle measured normal and parallel to peripheral cutting edge.
The values of these angles are found with the following formulas, referring to figure N°4.

$$\tan\gamma = \tan\gamma_b \cdot \sin\psi + \tan\gamma_s \cdot \cos\psi$$

$$\tan\lambda = \tan\gamma_b \cdot \cos\psi - \tan\gamma_s \cdot sin\psi$$

In figure N°5 are related the axial and radial angles, the angle of the peripheral cutting edge and effective rake angle γ measured in the direction normal to the cutting edge , while the diagram in figure N°6 is for determine the angle λ measured parallel to the cutting edge.
The example shown in the diagrams of figure N°5 and N°6 gets the following values:

$$\gamma_s = -10° \ \ ; \ \gamma_b = +5° \ ; \ \gamma = -3°36' \ ; \ \lambda = +10°34' \ ; \ \psi = 45°$$

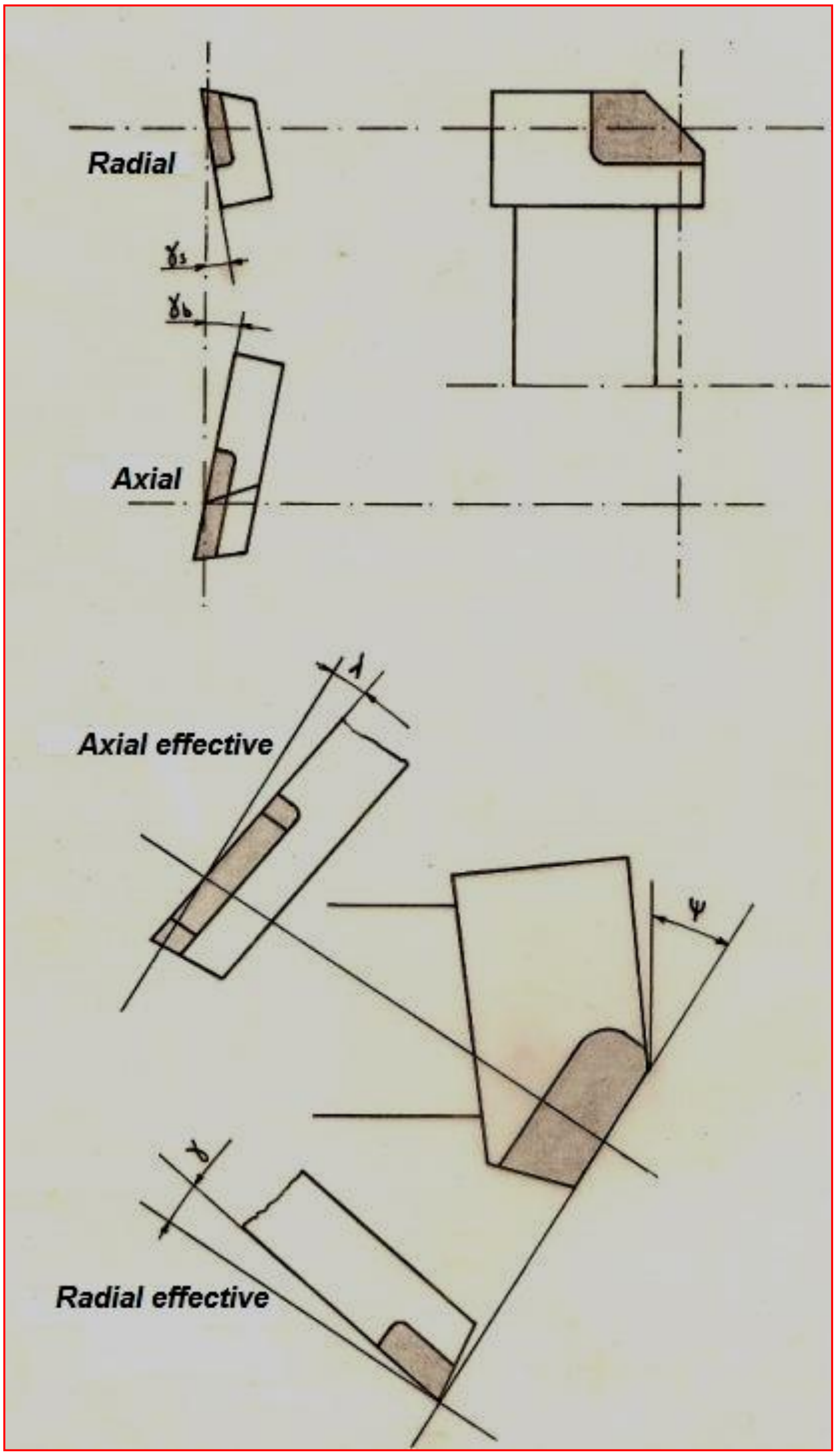

Fig. N°4- *Effective rake angles*

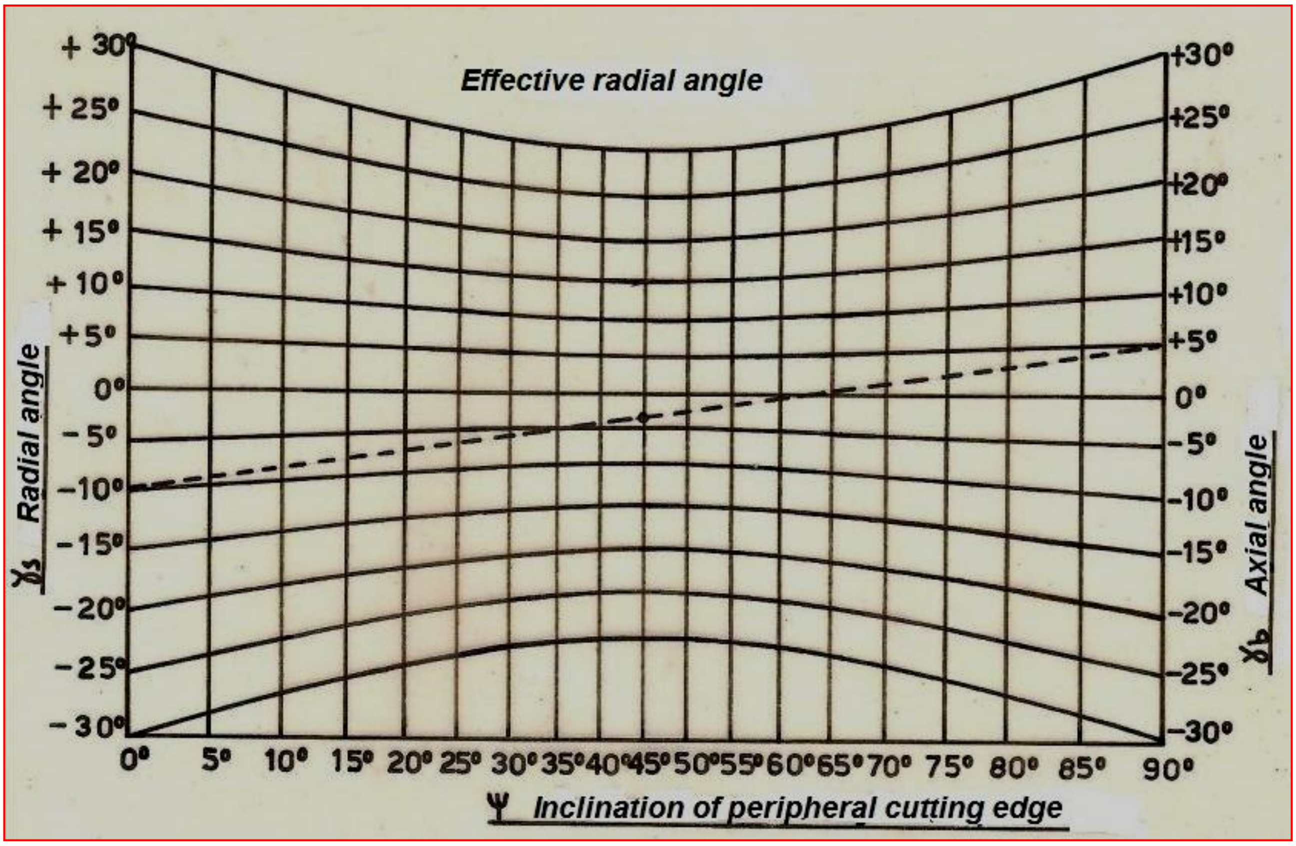

Fig. N°5- *Effective radial rake angle*

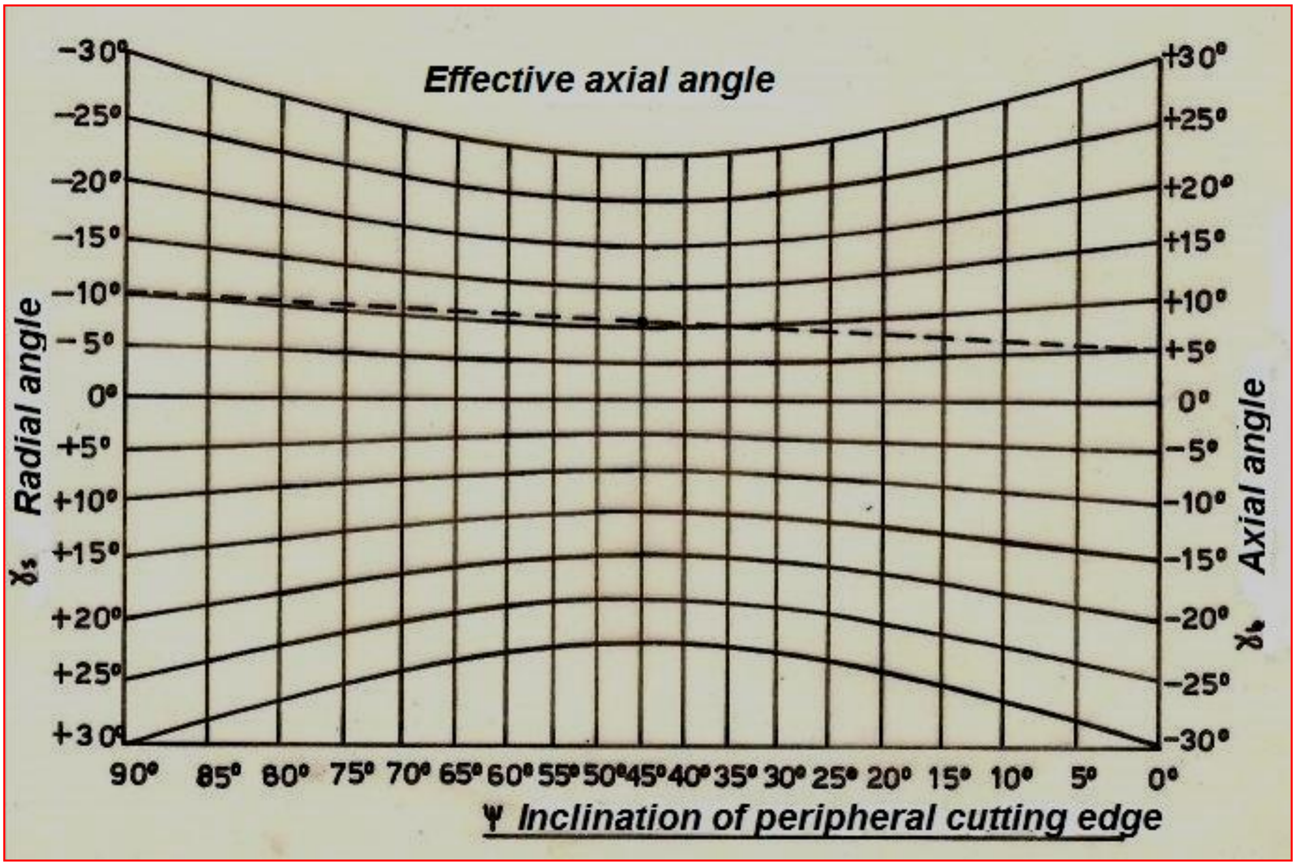

Fig. N°6- *Effective axial rake angle*